RESEARCH DEPARTMENT

An analogue to digital conversion system and paper tape transcoder for processing acoustic signals

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THE BRITISH BROADCASTING CORPORATION
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RESEARCH DEPARTMENT

AN ANALOGUE TO DIGITAL CONVERSION SYSTEM AND PAPER TAPE TRANSCODER FOR PROCESSING ACOUSTIC SIGNALS

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SUMMARY

A system has been devised to improve the technique of certain kinds of acoustical measurements concerned with sound diffusion and decay. Two main functions are incorporated. The first permits analogue to digital conversion of an electrical signal with recording on eight-track perforated paper tape at speeds of up to 120 characters per second. The second transcodes eight-track paper tape to five-track paper tape. The recording of data on paper tape in this way facilitates the use of electronic digital computers for data analysis, and consequently enhances efficiency, accuracy, and capability in dealing with acoustics problems. Current and projected applications of the system are briefly discussed.

1. INTRODUCTION

The potential usefulness of automatic processing equipment for the collection and analysis of acoustics data has been clear for some years. This is particularly evident in the assessment of sound diffusion and in the detailed analysis of sound level decay in studios and concert halls[1,2,3]. Almost all of the measurements associated with such investigations share a common basis; the studio is excited by steady or impulsive sound and the studio response is picked up by a microphone and analysed after separation into suitable frequency bands. The variation of the signal amplitude with time is generally the most important information. This report describes a system devised to save effort in the handling of data in this type of acoustical measurement, removing the manual and subjective work wherever appropriate and possible.

2. DATA PROCESSING

2.1. General

Two main functions are performed by the system. The first is the sampling of an electrical (analogue) signal and its conversion to digital form as a recording on eight-track punched paper tape. The second is the transcoding of eight-track tape to five-track tape which is acceptable as a data input medium on the BBC's Elliott 803B computer. It should be noted here that the reason for using eight-track rather than five-track tape in the first instance is that the resolution of one part in 32 (2^5) provided by five binary digits (bits) is generally inadequate in acoustical measurements, whereas the resolution of one part in 256 (2^8) provided by eight bits covers most requirements.

Most paper tape punches can perforate tape with five, six, seven and eight tracks. Thus, the same punch can be used for both functions. These two functions, "digitize" and "transcode", are selected by a master switch as illustrated in Fig. 1.

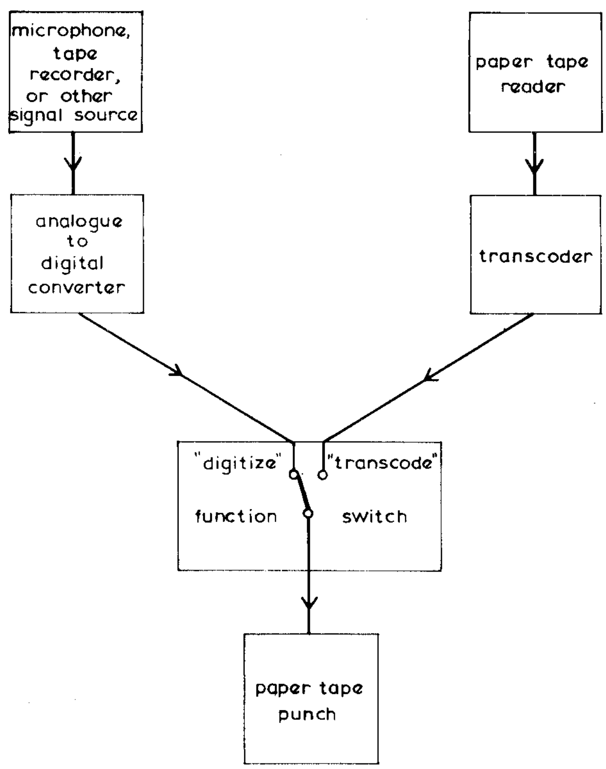


Fig. 1 - General schematic diagram of equipment

The equipment (Fig. 2) is broadly divided into three parts. The first is an analogue to digital converter, the second is an eight-track to five-track transcoder, and the third comprises driving and timing units. The action of each part in relation to the two system functions is described below.

2.2. Digitizing Function

2.2.1. Path of Signal through System

The analogue signal to be digitized is fed to the input of a commercial analogue to digital converter (ADC; Solartron model LP 1115.3) either directly or via a logarithmic amplifier.* The latter

*** The logarithmic amplifier built into the system is a transistorized unit designed by K.F.L. Lansdowne.**

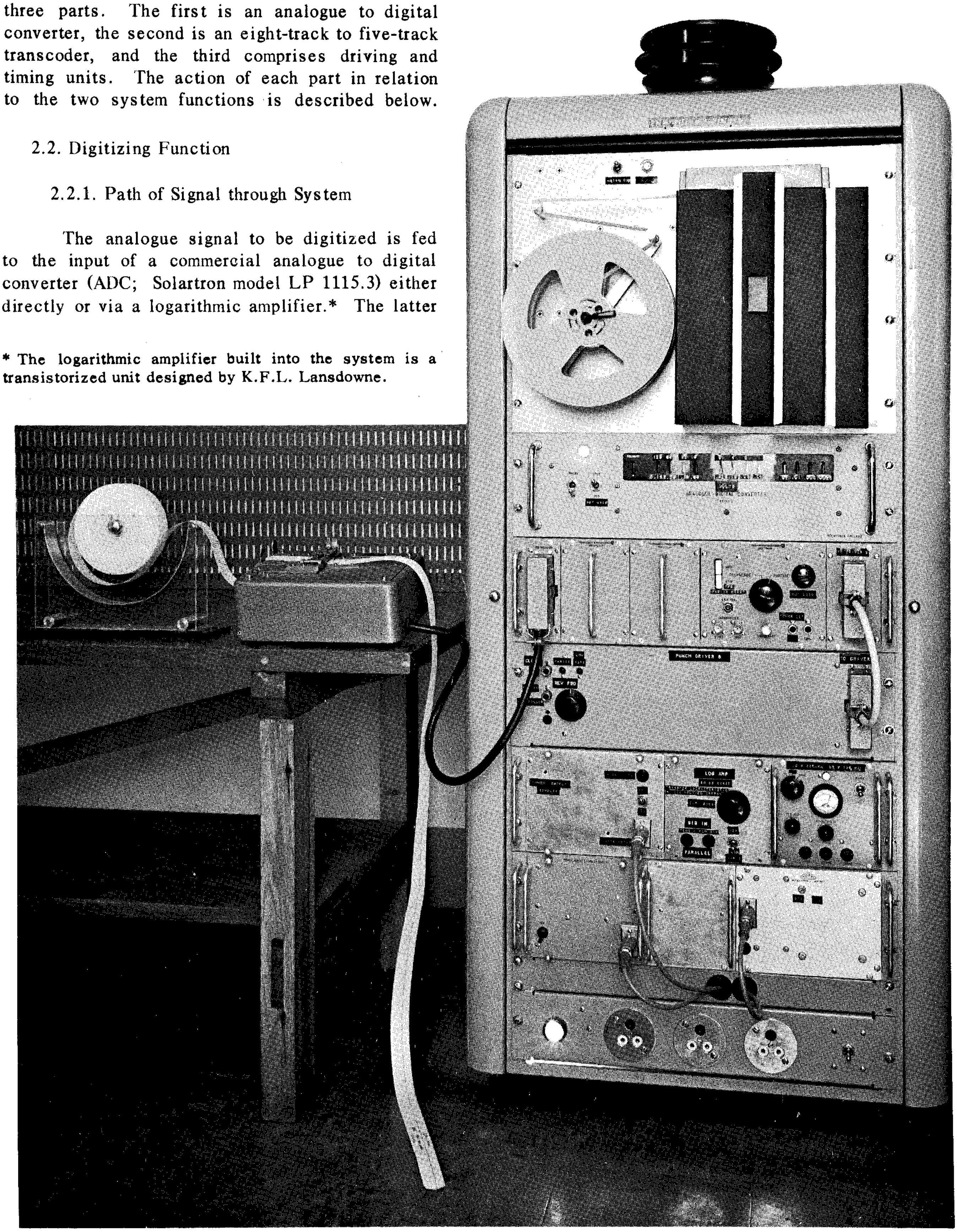


Fig. 2 - General view of the equipment

device, which is often used in sound-level decay analysis, acts as an amplifier and rectifier with a logarithmic transfer characteristic over a 50 dB range. The output of the ADC is on an eight-bit pure binary scale with a unit of 0·04 V and a corresponding maximum value of 10·20 V. The eight digit lines are connected to the eight data input gates of the punch driver and thence to the eight-track punch. A block diagram illustrating these signal paths is given in Fig. 3.

2.2.2. Timing

The "digitize" command pulse for the ADC is provided by a clock pulse former driven by an external oscillator whose frequency determines the sampling rate. If the rate is to be less than 10 samples per second, the oscillator frequency is divided externally. The maximum rate of 120 per second is determined by the maximum punching speed of the Tally P120 punch employed in the system. The ADC takes 80 μs to digitize each sample and so the punch clock pulse, which controls the punch driver circuits and is derived from the "digitize" command pulse, is delayed for a suitable period (140 μs) relative to the leading edge of the "digitize" command pulse. This sequence is shown in Fig. 4 together with the timing of the punch driver.

2.2.3. Control

Punching of the ADC output on paper tape is normally started by an external "start" command pulse applied to one side of a bistable element, and is continued until a "stop" command pulse is applied to the other side of the bistable element. As an alternative, internal provision is made for conversion to monostable operation with a set of running times appropriate to the digitizing of all acoustical decays normally encountered. The external pulses are provided by a special remote control box or by additional data processing equipment.

Provision is made for reversing the paper tape at low speed through the punch head without punching so that unwanted characters may be overpunched with a "delete" code recognized by the computer programme which analyses the data.

The production of blank leader tape is controlled by push buttons on the punch itself and on the remote control box. A protection circuit stops the punch and causes a warning lamp to go on when the supply reel of paper tape has almost run out. Production of blank leader tape is unaffected by this.

If the duration of the signal to be digitized is not more than about 15s, it is usually practicable to increase the effective sampling rate by a factor of ten by recording the signal on a continuous loop of magnetic tape and digitizing it several times. In this case "start" and "stop" command pulses are derived from the beginning and end of the signal, respectively. Unless the duration of the signal loop is an integral number of punch clock periods, the interval between the "start" command and the next "digitize" command will vary between zero

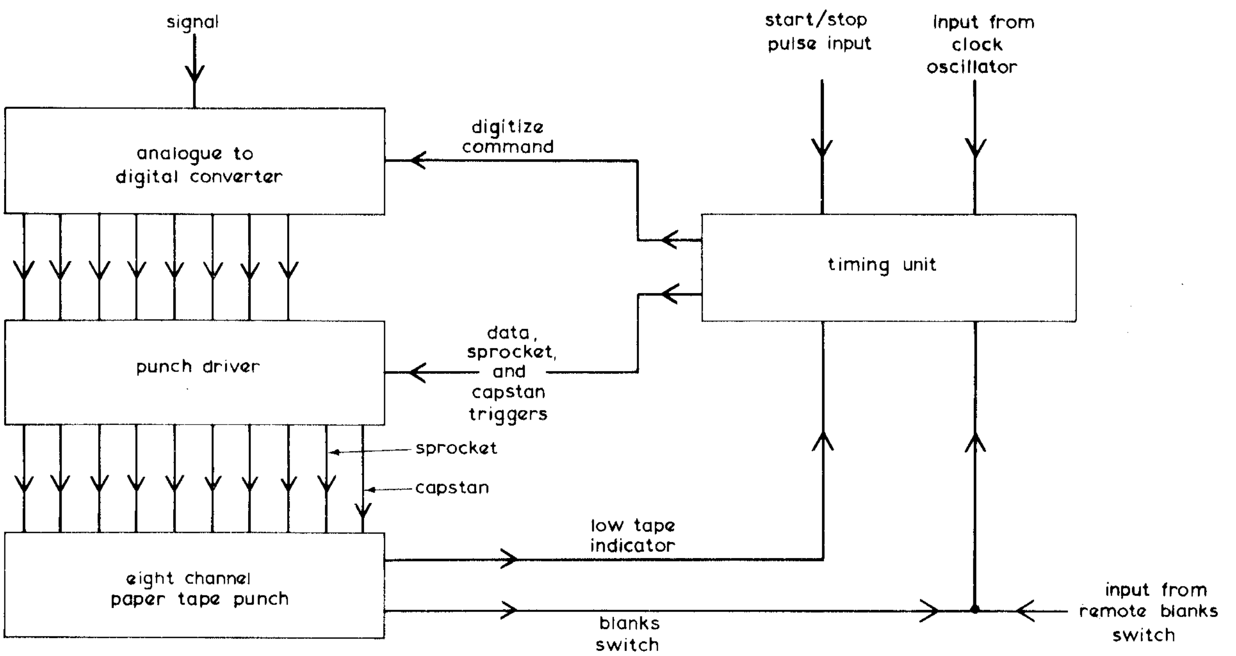


Fig. 3 - Block diagram showing signal paths during digitizing

and one punch clock period as successive loops are digitized. Since the digitizing time (80 μs) is less than one per cent of a punch clock period, the effective sampling rate can be increased by selecting sets of data with different starting times. The only extra information required for each set of data is the interval between the "start" command and the first subsequent "digitize" command or punch clock pulse. This parameter is measured with a digital chronometer connected to two panel mounted sockets bridging the "start" command and punch clock lines, respectively.

A facility for the external triggering of measuring instruments is provided by way of a socket connected to the contacts of a high speed relay which are closed when the bistable digitizing-control element is in the running state.

2.3. Transcoder Function

2.3.1. Path of Signal Through System

A tape reader transfers the data from eight-track paper tape to eight parallel data lines feeding eight AND* gates. The AND gates are in two groups of four the outputs of which are connected to four OR** gates, as illustrated in Fig. 5(*a*), each OR gate receiving the output of one AND gate in each group. The outputs of the four OR gates are fed to channels one to four of the punch, here set up for five channel working. Timing is arranged so that the outputs of the two groups of AND gates are punched alternately in successive five-track characters, the spare fifth channel being used to maintain an odd parity in the number of holes in a character, as depicted in Fig. 5(*b*). A parity digit generator ensures that the number of holes in each five track character is always odd, so that the most common fault encountered in paper tape punches and high-speed readers, namely the addition or subtraction of one hole from a character, can be detected by subsequent parity checks.

2.3.2. Timing

The estimated amount of data likely to be handled by the system does not justify particularly rapid transcoding, especially in view of the fact that the procedure is automatic and does not require continuous supervision. Therefore, a relatively cheap electro-mechanical reader with a maximum speed of 20 characters per second is used (Creed model 92). The reader signal is not available until

* AND gate : a gate whose output can be treated as "on" (or "1") only when all its inputs are "on" (or "1").

** OR gate : a gate whose output can be treated as "on" (or "1") when any of its inputs are "on" (or "1").

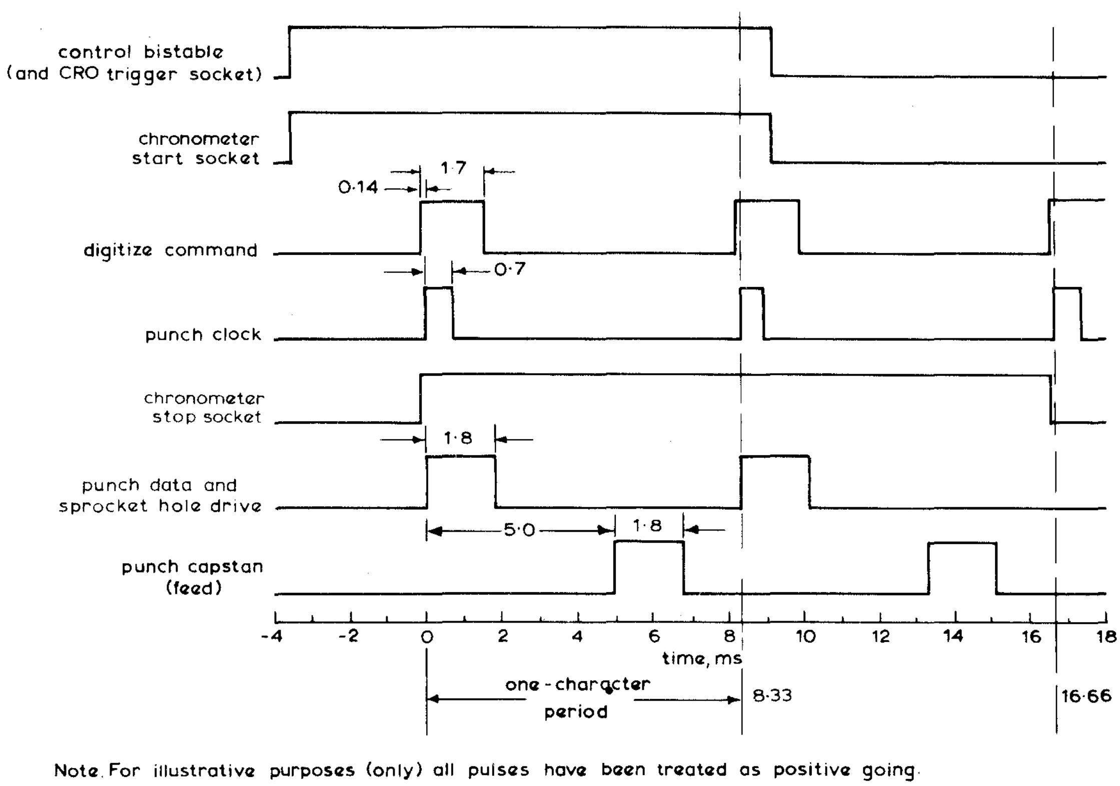
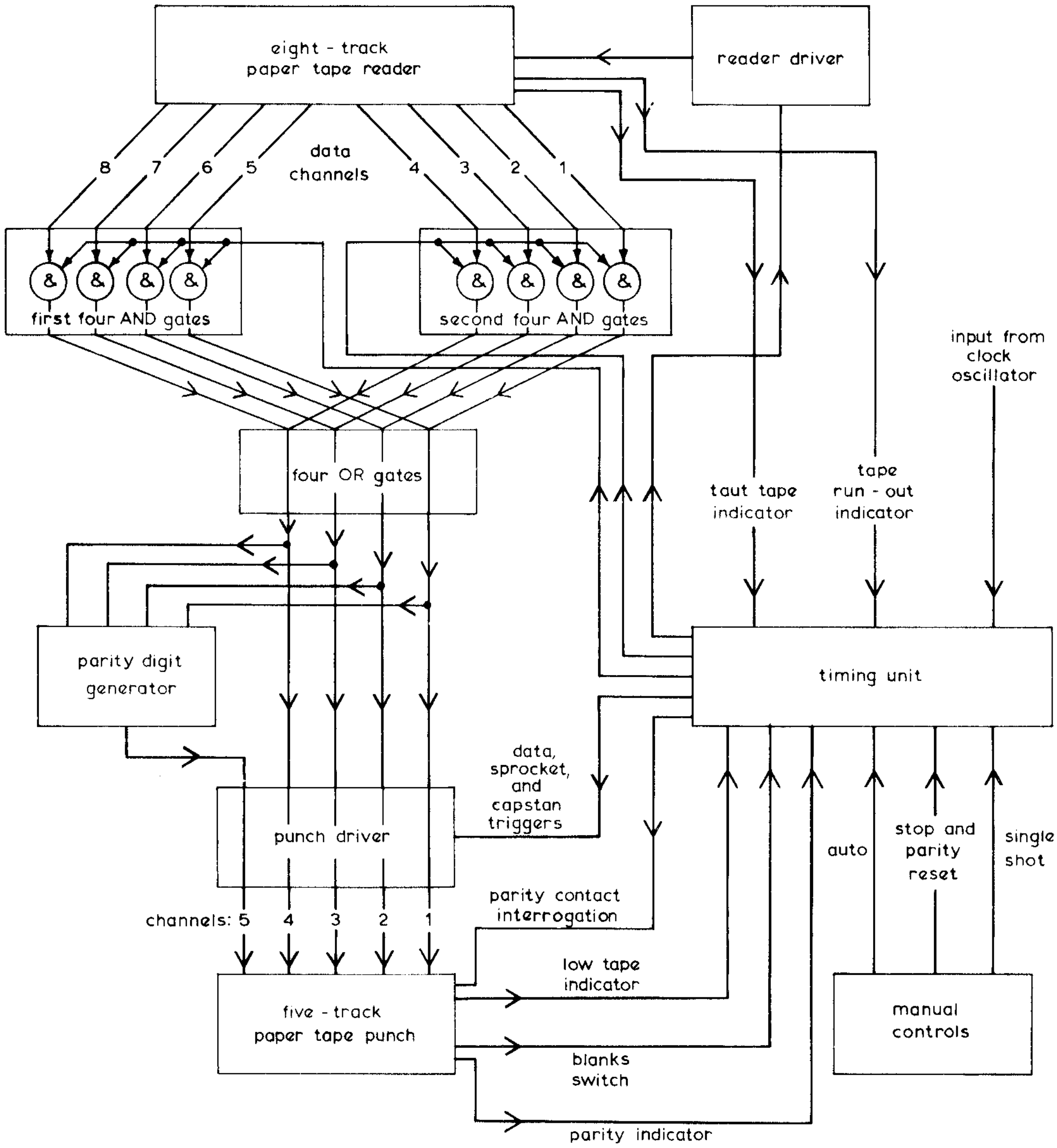
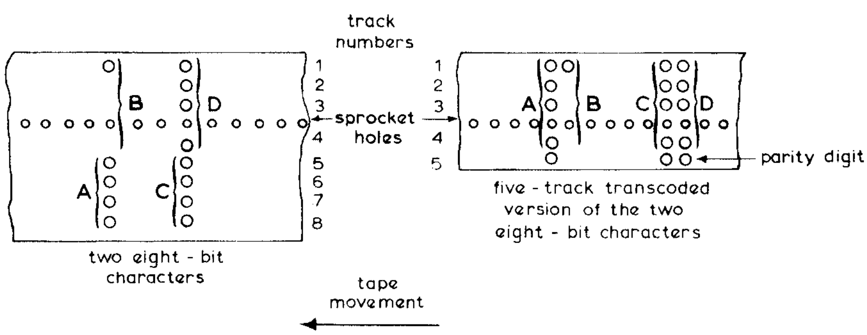


Fig. 4 - Timing of digitizing function at maximum speed



(a)



(b)

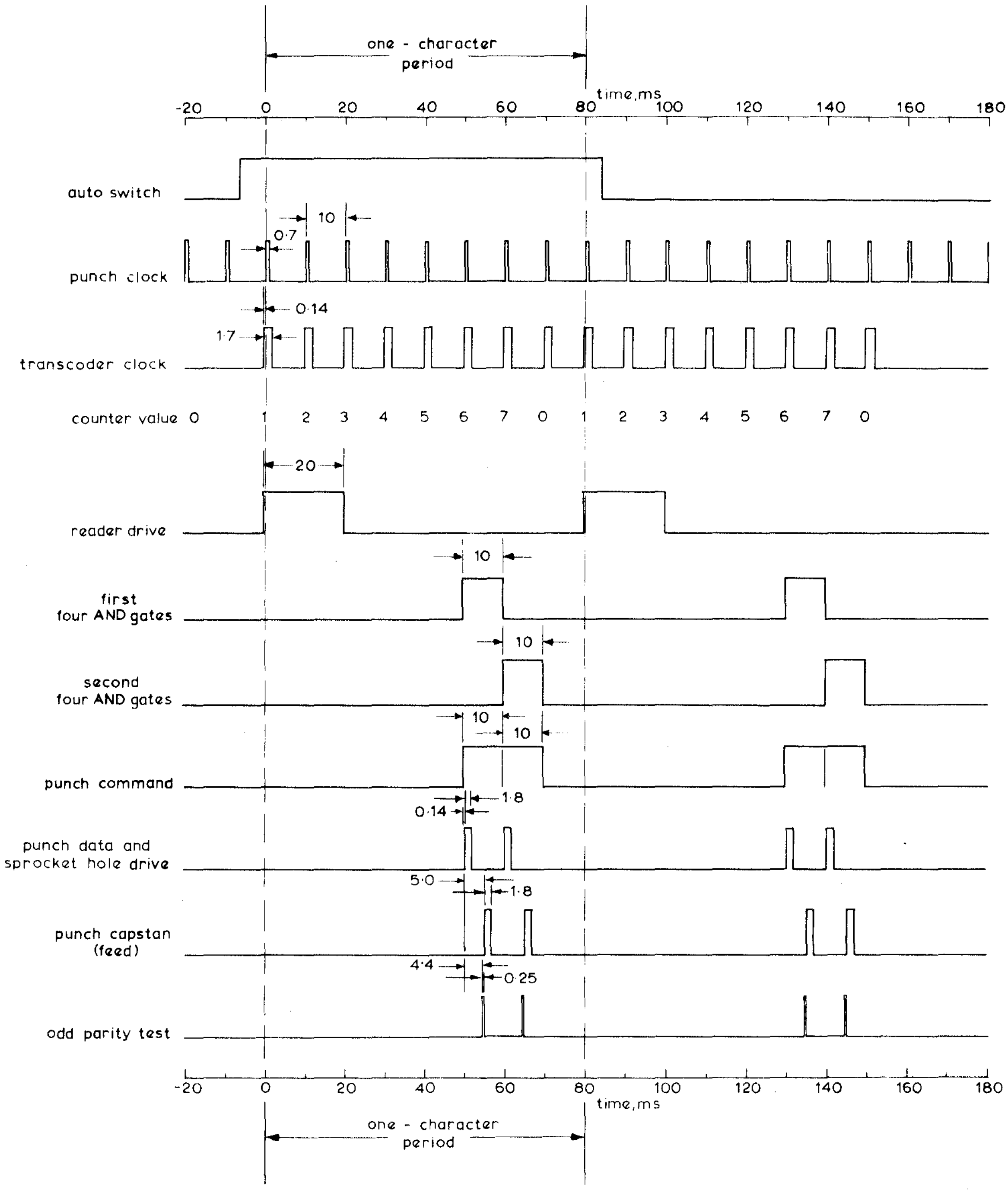
Fig. 5

(a) Block diagram showing signal paths during transcoding
(b) Eight-track characters and their transcoded five-track versions

at least 38 ms after the reader command, and the punch originally used in the system (Creed prototype model 100) has a fixed punch period of 10 ms (100 characters per second). It was therefore appropriate to arrange for the transcoder period to be 80 ms (12·5 eight-bit characters per second). The timing sequence is shown in Fig. 6.

2.3.3. Control

Push buttons are provided to set the transcoder to work continuously or on a "single shot" basis to facilitate editing. Odd parity checking is carried out after punching but before tape feeding, by interrogation of electrical contacts on the punch pins themselves. In the event of a parity failure the five-track character pair is completed, transcoding is suspended and a red lamp comes on. Remedial action depends upon the exact nature of the parity fault, but if the failure is not due to a permanent breakdown in the equipment, judicious use of the "single shot" and reverse feed facilities or a manual tape punch should rectify the situation.



Note For illustrative purposes (only) all pulses have been treated as positive going.

Fig. 6 - Timing of transcoding function at 12·5 eight-track characters per second

Detailed recommendations for remedial action are given in paragraph B11 of the Appendix.

In addition to the facilities for punching leader tape and testing the tape supply, protection circuits are provided to suspend transcoding if the eight-track tape feeding the reader becomes too taut or runs out.

3. CIRCUIT DESCRIPTION

Most of the basic logic circuits in the timing, transcoder, and punch driver units are made up of Elliott Minilog elements. A key to the circuital and symbolic forms of the elements is given in Fig. 7. A simplified circuit diagram of the system is given in Fig. 8. Components external to the Minilog elements are shown in the conventional manner and the signal conventions are explained in Section 3.3.

3.1. Timing Units Common to Both Functions

3.1.1. Clock Pulse Former

The negative lobes of a balanced sine wave signal from the external clock-oscillator trigger a monostable circuit to provide a 1·7 ms pulse used as the "digitize" command for the ADC and the clock pulse for the transcoder. A clock pulse for the punch is formed by passing the 1·7 ms pulse through a delay and differentiation circuit giving a 0·7 ms pulse, the leading edge being delayed by 0·14 ms relative to the leading edge of the 1·7 ms pulse. The 0·7 ms pulse is available with either polarity.

3.1.2. Data Gates on Punch Driver

The data gates on the punch driver are opened for 1·80 ms ± 0·1 ms in each punching cycle by a monostable circuit. For the digitizing function the monostable circuit is triggered by the 0·7 ms punch clock pulse after it has passed through one gate controlled by the digitizing-control bistable element and a second gate controlled by the contacts that indicate a low reservoir of paper tape. For the transcoder function, control of the first gate is switched to a primary gate line which permits punching of two characters when an octal counter (see section 3.2.1 below) registers counts of 6 and 7, as depicted in Fig. 6.

3.1.3. Sprocket-hole Driver Control

The sprocket-hole driver is controlled by an identical 1·80 ms pulse to that required for the data gates on the punch driver, but it is provided by a separate monostable. This monostable is triggered in the same way as that gating the data to the punch driver, except that an additional trigger is provided to facilitate the punching of leader tape, blank except for the sprocket hole, when the forward capstan is selected and the local or remote blanks switch is on. This additional trigger pulse is not inhibited if the tape supply to the punch runs out.

3.1.4. Forward Capstan Control

The forward capstan driver also is controlled by a 1·80 ms pulse, but the pulse is delayed by 5·0 ms ± 0·1 ms relative to the 0·7 ms punch clock pulse. A separate monostable and delay circuit provides the requisite pulse.

3.1.5. Reverse Capstan Control

The reverse capstan driver requires a 4·4 ms pulse. This is generated by a monostable triggered by the 0·7 ms punch clock pulse when the reverse capstan is selected and the local or remote blanks switch is on.

3.2. Transcoder Timing Units

3.2.1. Octal Counter

A three-stage serial binary counter driven by the 1·7 ms transcoder clock pulse controls the transcoding cycle. The state of the counter is sensed by five AND gates the outputs of which control the AND gates referred to in Section 2.3.1, the "punch" command line, the reader control bistable element, and the transcoder control bistable element, in accordance with the timing sequence shown in Fig. 6. The input to the counter is via a gate controlled by the transcoder control bistable element, the "taut tape" and "tape finished" contacts on the reader, and by the state of the counter itself to ensure that an integral number of transcoder cycles are completed and the counter set to zero if transcoding is suspended.

3.2.2. Transcoder Control Bistable Element

Depressing the "Auto" switch opens the input gate of the octal counter, and transcoding proceeds. If the "Stop" switch is then depressed, the octal counter gate comes under the control of the transcoder control bistable element which is caused to be in the "on" state except when the count is zero. Thus transcoding stops only when the count is zero and the current transcoder cycle has been completed.

Depressing the "Single Shot" button leaves the octal counter gate under the control of the

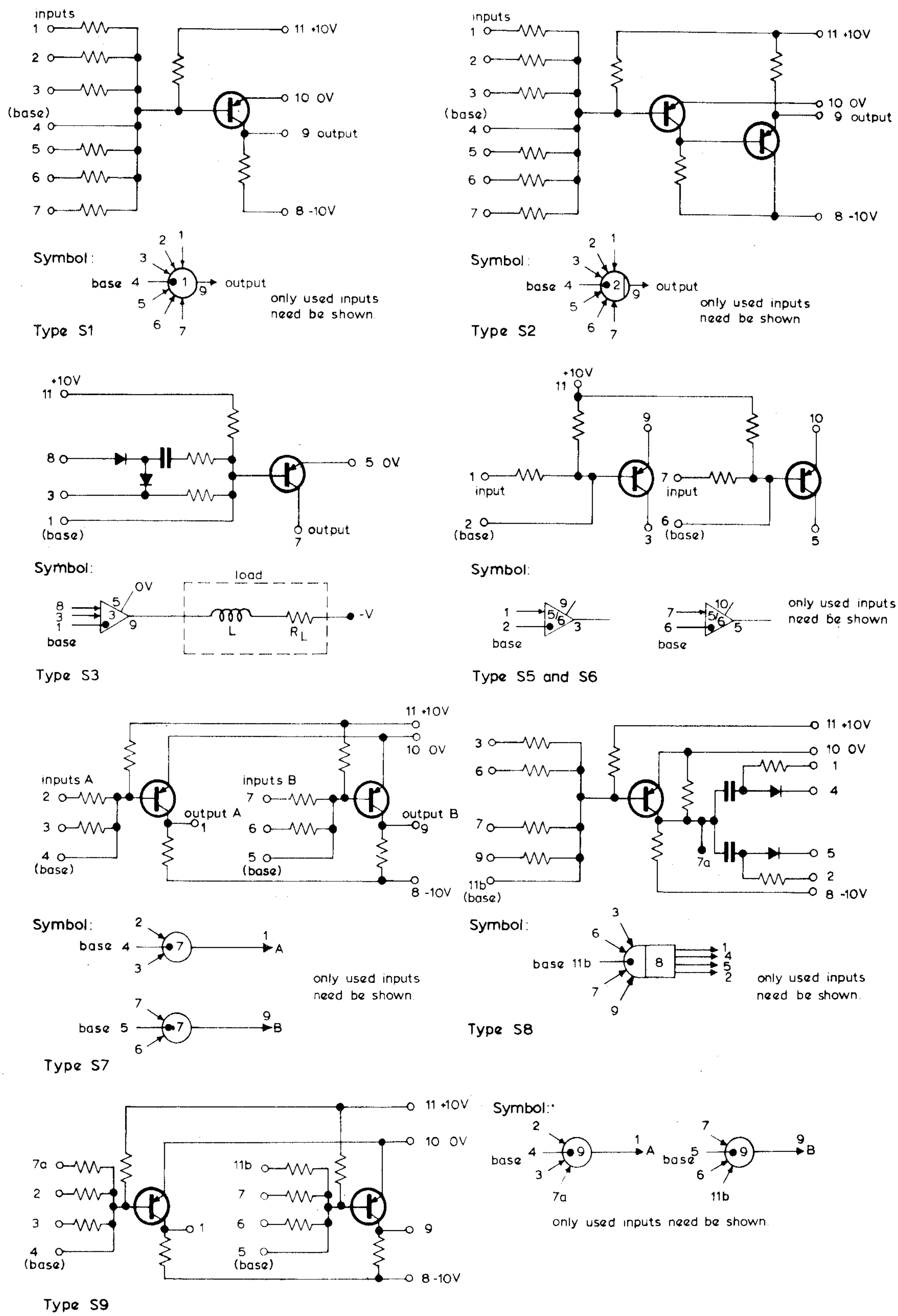


Fig. 7 - Minilog elements used in the system

Type S1, NAND gate
Type S2, NAND gate
Type S3, Switch
Type S5, Switch
Type S6, Switch
Type S7, dual NAND-gate
Type S8, pulse steering element
Type S9, dual NAND-gate

Convention: 0V corresponds to binary digit "1"

-10V corresponds to binary digit "0"

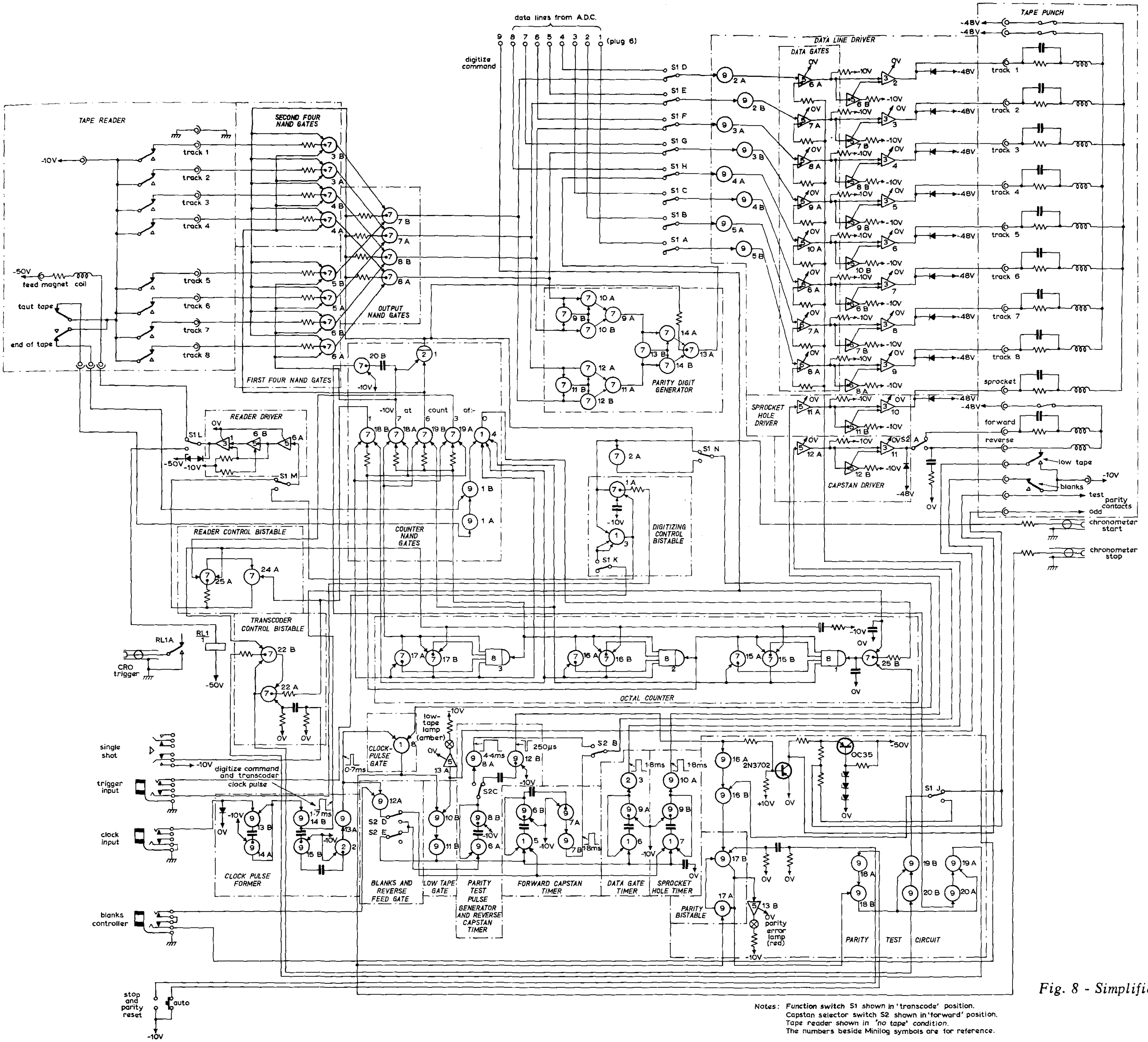


Fig. 8 - Simplified circuit diagram

Notes: Function switch S1 shown in 'transcode' position.
Capstan selector switch S2 shown in 'forward' position.
Tape reader shown in 'no tape' condition.
The numbers beside Minilog symbols are for reference.

transcoder control bistable element but changes the latter to the "on" state until the next count of zero is reached. Thus one transcoder cycle is carried out.

3.2.3. Parity Checking

The punch is provided with a set of contacts which senses the passage of the punch pins through the paper tape and which registers the "oddness" (or "evenness") of the number of holes punched. These so-called parity contacts are interrogated by a 0·25 ms parity test pulse delayed by 4·4 ms relative to the 0·7 ms punch clock pulse (see Fig. 6). This precedes the capstan pulse by 0·6 ms and it is therefore possible to inhibit the capstan pulse if a parity failure is detected. In the present equipment, the detection of an odd parity failure causes transcoding to stop at the end of the transcoder cycle containing the fault.

The timing of the parity check is as follows:

(a) When the punching cycle is started the parity bistable element is set to the "failure" state, but this has no immediate effect.

(b) If an odd number of holes is punched, the 0·25 ms parity test pulse resets the parity bistable element to the "pass" state.

(c) If the parity bistable element is not reset by the 0·25 ms parity test pulse, its "failure" state causes the octal counter input gate to close at the next count of zero, i.e. at the end of the current transcoder cycle. The "failure" state is indicated by a red warning lamp.

(d) The parity bistable element can be reset to the "pass" state and the red warning lamp extinguished by depressing the "stop" button.

3.3. Signal Conventions

The following signal conventions are used:

At the interfaces between the reader and transcoder, transcoder and punch, and ADC and punch, a level of -10V indicates a hole in the paper tape. If a level of -10V is taken to represent a binary digit "1", it can be seen from the circuit forms given in Fig. 7 that Minilog gates are inverted OR (NOR) gates, i.e. OR gates with their outputs inverted. If we *invert* the convention so that 0V indicates a binary digit "1" and -10V indicates a binary digit "0" they become inverted AND (NAND) gates, i.e. AND gates with their output states inverted. In designing the logic of the present system the latter convention was preferred, and consequently descriptions of logical actions in this report will treat Minilog gates as NAND gates, where 0V corresponds to a "1" and -10V corresponds to a "0".

3.4. Transcoder Data Logic

3.4.1. AND and OR Gates

The eight input AND gates and the four output OR gates were introduced in section 2.3.1 to simplify description of the transcoder. Their logical action is realised by eight NAND gates driving a further four NAND gates as shown in Fig. 8. This effects a saving of power and Minilog elements. Two of the timing gates connected to the octal counter control all 12 NAND gates and the final NAND gate in the parity digit generator (see sections 2.3.1, 2.3.2, and 3.4.2).

3.4.2. Parity Digit Generator

The logical basis of the odd parity digit generator is a consideration of a set of four objects, each object being one of two kinds. If we group the objects into two pairs and find either that the two objects are alike in each pair or that the two objects are different in each pair then there must be an even number of each kind of object in the set of four. In the transcoder, the states of the four data channels from the output NAND gates (see Fig. 8) constitute our four "objects". The likeness of channels one and two is examined by an "anti-coincidence" gate whose output is "1" (0V) only when the channels differ. The likeness of channels three and four is examined by a second "anti-coincidence" gate, and a similar third gate examines the likeness of the outputs of the first two gates. If the number of holes (-10V) about to be punched on tracks one to four is even, the output of the third gate provides a signal to punch a hole in track five, thereby making the total number odd.

3.5. Punch Driver

The driver for the Tally P120 punch comprises a set of three-stage pulse amplifiers which transform the low-level signal pulses to 1·4A at -48V. These pulses operate clutches through which power is transmitted from the 1/8 H.P. punch motor to the punch pins and capstan.

The system originally used a Creed prototype model 100 punch, and the Creed punch driver is still present in the equipment. It can be wired into the system without great difficulty so that the Tally punch can be temporarily replaced by the Creed punch in the event of a breakdown.

4. RELIABILITY

Since the time that all the equipment specifications were met no errors in either eight-track or five-track characters have been detected, and several million digitized samples have been successfully recorded and transcoded. However, several unjustified failures of the parity test have occurred, due to unreliable wiring between the parity sensing contacts on the punch. Also, the tape reader has proved to be somewhat unreliable. These faults do not seriously hinder operations, and it is likely that they will be overcome soon.

5. APPLICATIONS

The system parameters were chosen with the following practical applications in mind.

(a) The assessment of diffusion in studios and concert halls[1,2] by computer analysis of digitized sound-decay curves. Preliminary tests of this technique have been successful and are continuing.

(b) The measurement of diffusivity[3] by digital sampling of directional distributions of sound energy flux detected by directional microphones. The analysis of such measurements is currently being carried out.

(c) The processing of reverberation time and other test data directly and from magnetic tape recordings. A scheme for measuring reverberation time using pre-recorded excitation tapes has been in operation for about two years. In recent months the tape recorded decay data has been processed by the system described here. Further automatic test-tape handling equipment is now in use and will form the subject of a further report.

(d) The processing of analogue and digital data from laboratory measuring instruments. Digital data is fed into the system at the ADC/punch interface. For example, paper tape recording of the digital output from the meter indication analyser recently developed by the former Audio-Frequency Section has been carried out in this way.

Detailed operation instructions for the equipment are given in the Appendix.

6. CONCLUDING REMARKS

The equipment described represents part of the effort being made in acoustics to exploit the benefits of electronic digital computers. Apart from well known advantages of data processing by computer, such as improved accuracy and efficiency, the speed with which complex functions and procedures can be examined makes possible the development of theories to explain many acoustical phenomena which are not yet fully understood. A recent example of all these benefits can be seen in the work of Schroeder et al,[4,5] on new methods of analysing sound-decay data.

Care was taken in the design of the equipment to ensure that its development could continue and that it would not quickly become obsolete. The speed of the ADC was chosen partly in the light of economic factors and partly in anticipation of envisaged uses of the ADC connected to a computer either directly ("on line") or via a high-speed storage system. If such use of the ADC becomes a reality, detailed analysis and processing of sound could be carried out, and knowledge of acoustics could thereby be enhanced. For example, normally impractical measurements and computations concerning sound energy distribution in space and time, having an important bearing upon diffusion and and quality, could be readily carried out. Also, the way would be open to digital processing of programme signals within the broadcast chain.

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APPENDIX

Data Processing Equipment: Operating Instructions

A Analogue to Digital Conversion

A1. Ensure that −48V power supply is switched off before connecting the equipment bay to the mains.

A2. Connect the bay to the mains and switch on the + 10V, −10V and −50V power supplies. Switch on analogue to digital converter (ADC) and punch motor.

A3. Connect CLOCK IN jack of punch driver B to a zero level oscillator (10 Hz $\leqslant$ frequency $\leqslant$ 120 Hz) or to frequency divider on counter unit Mark 1/1 if the digitizing rate is less than 10 per second.

A4. Connect the REMOTE PUNCH-CONTROL BOX jacks to the bay as follows:-

POWER to POWER OUT

TRIG to TRIG

RUN OUT to BLANKS CONTROLLER

A5. Check that REV/FWD switch on punch driver B is set to FWD, and that the LOW TAPE amber lamp is off. If the LOW TAPE amber lamp is on, re-load the punch with 25·4 mm (1 inch) A1 paper tape according to the instructions in the Tally P120 manual.

A6. Check that punch is loaded with 25·4 mm (1 inch) A1 paper tape. If necessary change the white plastic tape guide to accommodate the 25·4 mm (1 inch) tape (see Tally Instruction Manual for details); also empty the chad box if necessary.

A7. Set FUNCTION switch on punch driver A to DIGITIZE and switch on −48V power supply (punch driver).

A8. The signal to be converted can be fed to the ADC in three ways:

(a) Direct. The signal is connected to plug B of the ADC (see Solartron ADC Manual for details).

(b) Via logarithmic amplifier (LOG AMP). The signal (+ 4 dBm max) is connected to the SIG IN jack of the LOG AMP on the bay, the input impedance of which can be switched to either 600 ohms or 10 kilohms. The output of the LOG AMP is normally connected to plug B of the ADC inside the bay. The maximum decay rate of the LOG AMP is 600 dB per second. The transfer characteristic has a slope of $-0{\cdot}141\text{V.dB}^{-1}$ and the range of linearity is from about + 4 dBm down to −46 dBm. The output bias control should normally be set so that a zero level input signal gives an output voltage of about 2·56V (64 ADC units).

(c) Via Set-Output Amplifier (SOA). The signal (+ 16 dBm max, −35 dBm min) is connected to the input (600 ohms) of the set-output amplifier (SOA) on the bay. The gain of the SOA automatically adjusts itself after a manual reset or a −10V step has been applied to the tip of the AUTO RESET jack, so that the maximum level is + 4 dBm at the output jack (600 ohms).

This maximum output level is designed to equal the maximum input level of the LOG AMP to which it is normally connected.

A9. Set the oscillator frequency to the required digitizing rate. This must not exceed 120 Hz. It is usually necessary to run out about 0·5m of blank tape at 120 characters per second before commencing a run. The blanks can be produced either by pressing the white button marked BLANKS on the punch itself or the white button marked RUN OUT on the REMOTE PUNCH-CONTROL BOX.

A10. To start punching the digitized signal, press the black button marked PUNCH on the REMOTE PUNCH-CONTROL BOX. The signal fed to the ADC will then be punched in pure binary form on the paper tape.

A11. To stop punching, press the black button marked STOP on the REMOTE PUNCH-CONTROL BOX.

B. Eight-Track to Five-Track Paper Tape Transcoding

B1. Check that −48V power supply is switched off before connecting the bay to the mains.

B2. Connect the bay to the mains. Connect the Creed model 92 reader to the bay and switch on the +10V; −10V and −50V power supplies.

B3. Check that the REV/FWD switch on punch driver B is set to FWD. If the LOW TAPE amber lamp is on reload punch with 17·5 mm (11/16 in.) A1 paper tape.

B4. Check that the punch is loaded with 17·5 mm (11/16 in.) A1 paper tape. Change the white plastic tape guide if necessary (see Tally P120 Punch Manual).

B5. Connect an oscillator delivering zero level at 100 Hz to the CLOCK IN jack of punch driver B.

B6. Set FUNCTION switch on punch driver A to TRANSCODE and check that white piano key switch is set to STOP.

B7. Place leader of eight-track tape in the reader.

B8. To transcode at full speed press the piano key switch marked AUTO.

B9. To stop transcoding press the piano key switch marked STOP.

B10. To transcode one eight-track character at a time press the white button marked SINGLE SHOT on punch driver A.

B11. Parity checking. The punch will automatically stop after punching a pair of five-track characters (corresponding to one eight-track character) if one or both of them does not have an odd number of holes.

In the event of such a hold-up, check that the last two characters punched each have an odd number of holes. If they have, press the STOP AND PARITY RESET piano-key switch. This will clear the hold-up and extinguish the red parity lamp on punch driver B. Transcoding can then be recommenced by pressing the piano-key marked AUTO. If one or both of the last two characters punched has holes missing, the following procedure should be carried out:

(a) Decrease punch clock rate to about 1 Hz (by using frequency divider).

(b) Set REV/FWD switch to REV.

(c) Inch the tape backwards two characters by pressing the white button on the punch marked BLANKS.

(d) Move the eight-track tape back one character in the reader.

(e) Set the REV/FWD to FWD.

(f) Increase the punch clock rate to 100 Hz.

(g) Press the SINGLE SHOT button. If the transcoded characters are now correct proceed transcoding at full speed. If not, a detailed check of the equipment will be necessary unless the transcoding fault involved the perforation of too many holes. In the latter event it will probably be necessary to recommence transcoding at the beginning of the eight-track tape unless a special character, which is ignored by the computer programme, can be manually punched over the faulty character.

C. Direct Connection to Punch Data Lines

The FUNCTION switch must be set to DIGITIZE. Starting and stopping of punching is carried out using the REMOTE PUNCH CONTROL BOX described in para. A4.

The 12-way Painton plug PL6 on the back of punch driver A is connected to the punch data channels as follows:-

PL6 Pin No.	Punch Channel Number
1	8
2	7
3	6
4	1
5	2
6	3
7	4
8	5

The signal convention at PL6 is:

-10V	=	Hole
0V	=	No hole (0V is programme earth as on pin 12, PL6)

A -10V punch clock pulse of duration 0·7 ms is provided on pin 11 of PL6. This is to facilitate the requirement that the data signals on pins 1 to 8 MUST NOT be changed for a period of 1·8 ms ± 0·1 ms after the leading edge of the punch clock pulse. It is during this 1·8 ms period that the data signals are amplified and passed through to the clutch banks on the punch.

Although odd parity testing is executed during punching, no action is taken as a consequence, and so any number of data channels may be used.

D. General Notes

D1. The need to keep the -48V power supply switched off except when running the punch is stressed because the punch clutch banks which it drives can be easily damaged. The precautionary technique described above avoids incorrect connection of power to the clutches because of spurious logic pulses caused by mains switching operations.

D2. The sockets and controls on the bay not mentioned above are as follows:

C.R.O. TRIG

This Pye socket provides a short circuit when the bistable digitize-control element is "on".

CHRONOMETER START

A -8V level is provided at this BNC socket when the bistable digitize-control element is "on".

CHRONOMETER STOP

The 0·7 ms, -10V punch clock pulse appears at this BNC socket.

MANUAL RESET ON SOA

Self-explanatory.

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